Plant Community Response in Small Plots One Year after Treatment with Triclopyr and Endothall in Noxon Rapids Reservoir, MT, 2011

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A Report Submitted to Sanders County, MT, the Montana Weed Trust, and the U.S. Army Engineer Research and Development Center

November 2011

Geosystems Research Institute Report #5049

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **NOV 2011**	2. REPORT TYPE	3. DATES COVERED **00-00-2011 to 00-00-2011**

4. TITLE AND SUBTITLE **Plant Community Response in Small Plots One Year after Treatment with Triclopyr and Endothall in Noxon Rapids Reservoir, MT, 2011**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Mississippi State University,Geosystems Research Institute,Mississippi State ,MS,39762**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**21**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Preface

This report presents data collected by the Geosystems Research Institute, Mississippi State University in 2010 and 2011 on Noxon Rapids Reservoir. Funding was provided by a grant under the American Recovery and Re-Investment Act and the Montana Weed Trust as a subcontract from Sanders County, Montana to Mississippi State University. We also thank Celestine Duncan, Brian Burke, Heidi Sedivy, and John Halpop for assistance with planning and on the ground logistics. Field assistance was provided by Dr. Wade Givens, Dr. Eric Dibble, Amanda Fernandez, Jonathan Fleming, and Cheryl McLaurin, all from Mississippi State University. Any errors in presentation or fact, however, are the responsibility of the authors.

Plant Community Response in Small Plots One Year after Treatment with Triclopyr and Endothall in Noxon Rapids Reservoir, MT, 2011

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Introduction

Aquatic plants are important to lake ecosystems (Madsen et al. 1996, Wetzel 2001) and are essential in promoting the diversity and function of an aquatic system (Carpenter and Lodge 1986). Littoral zone habitat and associated plants may be responsible for a significant proportion of primary production for the entire lake (Ozimek et al. 1990, Wetzel 2001). Littoral zone habitats are prime areas for the spawning of most fish species, including many species important to sport fisheries (Savino and Stein 1989). Furthermore, aquatic plants anchor soft sediments, stabilize underwater slopes, remove suspended particles, and remove nutrients from overlying waters (Barko et al. 1986, Doyle 2000, Madsen et al. 2001). The introduction of non-native plants into littoral zone habitats often alters the complex interactions occurring in these areas (Madsen 1998). Dense stands of non-native plants are often responsible for reduction in oxygen exchange, depletion of dissolved oxygen, increases in water temperatures, and internal nutrient loading (Madsen 1998).

Eurasian watermilfoil (*Myriophyllum spicatum* L.) is a non-native invasive species that, when present, has been associated with declines in native plant species richness and diversity (Madsen et al. 1991, Madsen et al. 2008). Eurasian watermilfoil also poses nuisance problems to humans in the form of increasing flood frequency and intensity, impeding navigation, and limiting recreation opportunities (Madsen et al. 1991). Furthermore, the establishment of Eurasian watermilfoil and subsequent spread is likely perpetuated by the ease of fragmentation (both physical and physiological) of this plant, water movement within the reservoir, and high watercraft traffic that moves fragments to new areas.

Although the impacts form Eurasian watermilfoil are numerous, controlling this species is often difficult and unpredictable. Flowing water, such as the Lower Clark Fork River, further complicates the use of herbicides as water flow will increase the dilution and dissipation of the herbicides. Herbicide applications in run of the river reservoirs are often subject to more extreme perturbations than those of natural lakes. Run of the river reservoirs have variable water-exchange patterns, typically tied to dam operations, which will impact aqueous distribution of herbicides resulting in reduced chemical exposure times against target plants and unacceptable effectiveness (Getsinger et al. 1997).

The use of auxin mimicking herbicides such as 2,4-D and triclopyr, and the contact herbicide endothall have been used extensively for Eurasian watermilfoil control. Additionally, herbicide concentration exposure time (CET) relationships have been designed under controlled conditions to guide management decisions on choosing the correct herbicide concentration with respect to contact time (Netherland et al. 1991, Netherland and Getsinger 1992). However, little data exists with respect to combining a contact herbicide with a systemic herbicide to reduce the exposure

time requirements and maintain plant control. Mesocosm trials of herbicide combinations resulted in reduced contact time needed for effective Eurasian watermilfoil control, while maintaining the benefits of the longer term control afforded by the systemic herbicide (Madsen et al. 2010). Though small scale trials have been conducted, there has been limited field assessment of this herbicide combination. Pursuant to this, effective herbicide concentrations used in field situations still need to be determined; and the selectivity spectrum of non-target plants to this combination is still unknown. Therefore, our objectives of this study were to:

1) Demonstrate at the field scale the effectiveness of combining triclopyr with endothall for control of Eurasian watermilfoil and curlyleaf pondweed in flowing systems.

2) Evaluate the aquatic plant community response to herbicide treatments one year after treatment.

Materials and Methods

Point Intercept Assessments. Pretreatment (0 weeks after treatment (WAT)) point intercept surveys were conducted on July 20, 2010 using a 50 m grid to assess the plant community in four plots on Noxon Rapids Reservoir prior to herbicide application. The four plots selected were based on surveys conducted throughout the reservoir in 2008 and 2009 (Madsen and Cheshier 2009, Wersal et al. 2009, Wersal et al. 2010a). Plots 2 (23.8 acres) and 4 (28.5 acres) served as our untreated reference plots, meaning no herbicides were placed in these plots. Plot 7 (28.3 acres) was treated with triclopyr alone, and plot 8 (15.8 acres) was treated with the combination of triclopyr + endothall. Additional surveys of each plot occurred at 7 WAT and 52 WAT to assess herbicide efficacy on Eurasian watermilfoil and curlyleaf pondweed; as well as to assess non-target effects on the entire aquatic plant community.

Survey methods were similar to those utilized during recent projects in the Pacific Northwest (Madsen and Wersal 2008, Madsen and Wersal 2009, Wersal et al. 2010a, Wersal et al. 2010b). A total of 36, 38, 35, and 37 points were surveyed in Plots 2, 4, 7, and 8 respectively. Surveys were conducted by boat using Global Positioning System (GPS) technology to navigate to each point. Survey accuracy was 1-3 m (3-10 ft) depending on satellite reception. At each survey point, a weighted thatch rake was deployed to determine the presence of plant species. Spatial data were recorded electronically using FarmWorks Site Mate® software (Hamilton, IN). The software allowed for in-field geographic and attribute data collection. Data were recorded in database templates using specific pick lists constructed exclusively for this project. Site Mate® provided an environment for displaying geographic and attribute data and enabled navigation to specific locations on the lake.

Statistical Analyses. Plant species presence was averaged over all points sampled and multiplied by 100 to calculate percent frequency. Changes in the occurrence of plant species between the pretreatment survey and 7 WAT and 52 WAT surveys were determined using the McNemar's test. The McNemar's test is used to assess the differences in the correlated proportions within a given data set between variables that are not independent, i.e. sampling the same points pre- and post-treatment (Stokes et al. 2000, Wersal et al. 2006, Wersal et al. 2010b).

All comparison were made back to pretreatment plant occurrence. Mean species richness, native species richness, and non-native species richness was calculated for each plot and subjected to a general linear model. If a significant difference in species richness was detected, means were separated using a Fisher's Protected LSD test. All analyses were conducted at a $p < 0.05$ significance level.

Results and Discussion

Plot 7 (Triclopyr Only)

The presence of Eurasian watermilfoil in Plot 7 significantly declined from 50% before herbicide treatment to 16% 7 WAT and 12% 52 WAT (Table 1 and Figure 1). This represents 70% and 76% control respectively for the 7 and 52 WAT surveys. Curlyleaf pondweed was observed at 81%, 50%, and 67% of survey points during the pre, 7, and 52 WAT surveys respectively (Figure 2). The decline in plot 7 is most likely due to natural senescence (Woolf and Madsen 2003), as plants had produced turions and were falling out of the water column during the time of the 7 WAT survey. In the spring of 2011, the lower Clark Fork River systems experienced a higher than average snow-melt resulting in high water conditions for most of the summer. The high water reduced light penetration and likely kept water temperature below normal. These factors likely resulted in delayed germination and sprouting of most plant species and thus during the 52 WAT survey curlyleaf pondweed was still actively growing in more locations in the plot.

No significant impact was observed from the herbicide application on native plant species at either the 7 WAT or 52 WAT surveys. Species richness and native species richness were not different between survey times as well. The presence of elodea in this plot increased from the pretreatment survey to the 52 WAT survey, suggesting that as Eurasian watermilfoil was removed Elodea was able to re-colonize those areas. Similar results were observed in Hayden Lake, ID when applications of 2,4-D and triclopyr were made for Eurasian watermilfoil control (Wersal et al. 2010b). The use of triclopyr alone resulted in very selective control of Eurasian watermilfoil for at least a full year after treatment, a result due to the CET achieved after treatment (Wersal and Madsen 2011). A longer exposure time would have likely resulted in non-target plant injury, especially to northern watermilfoil (*Myriophyllum sibiricum*) and white water-buttercup (*Ranunculus aquatilis*).

Plot 8 (Triclopyr and Endothall)

Eurasian watermilfoil in plot 8 significantly declined by 7 WAT and control was maintained to 52 WAT with the combination of triclopyr + endothall (Table 2). Eurasian watermilfoil was observed at 63%, 9%, and 5% of survey points during the pretreatment, 7 WAT, and 52 WAT surveys respectively (Figure 3). These results represent 92% reduction in Eurasian watermilfoil occurrence out to 52 WAT. The presence of curlyleaf pondweed also significantly declined from 74% pretreatment to 3% 7 WAT (Figure 4). Curlyleaf pondweed was found at 43% of the survey points at 52 WAT. The decline at 7 WAT was likely due to the endothall applied in the plot. Endothall, being a contact herbicide, would have had an immediate effect plants in the year of treatment. Curlyleaf pondweed has begun to recover as indicated by the 52 WAT survey.

The combination of triclopyr + endothall was much less selective in plot 8, as there were impacts to the native plant community. All species richness metrics for both the 7 and 52 WAT surveys were lower than what was estimated during the pretreatment surveys. The presence of elodea increased during the 52 WAT survey, again likely due to opening new areas for expansion and growth by the herbicide application. Although, the combination herbicide treatment was effective there will be a trade-off in selectivity when compared to using triclopyr alone. Given the estimated half-life for dye and herbicide in plot 8 (Wersal and Madsen 2011), triclopyr applied alone would have been much less effective. In areas where there is potential for high water exchange, the combination treatment would be necessary to maximize control.

Plots 2 and 4 (Untreated Reference Plots)

The plant community in plot 2 has changed little over the course of the study. Eurasian watermilfoil was found at survey points during the post treatment surveys where it was not observed during previous surveys, suggesting that the population in plot 2 is expanding, though statistical differences in presence have not been detected (Table 3). Species richness did not change between any of the surveys. The locations of Eurasian watermilfoil and curlyleaf pondweed for plot 2 are depicted in figures 5 and 6 respectively.

The presence of Eurasian watermilfoil in plot 4 did not change between the pretreatment survey and the 7 and WAT surveys (Table 4). Therefore, the reductions observed in Eurasian watermilfoil in plots 7 and 8 can be attributed to the herbicide applications. The locations of Eurasian watermilfoil and curlyleaf pondweed for plot 4 are depicted in figures 7 and 8 respectively.

Conclusions. Herbicide applications were effective at reducing the presence of Eurasian watermilfoil in the treated plots, 76% and 92% for plots 7 and 8 respectively to 52 WAT. Control of Eurasian watermilfoil is achievable in flowing water systems if there is an understanding of water exchange characteristics at a given site. Water exchange is likely to be site specific within Noxon so additional studies are needed, especially upstream, to develop a water exchange data set for portions of the reservoir to base management decisions on.

Our data indicate that Eurasian watermilfoil can be selectively removed from areas of Noxon, and that native species will rapidly re-colonize areas once inhabited by Eurasian watermilfoil. Furthermore, these data suggest that Eurasian watermilfoil control can be maintained for at least two growing seasons with a single herbicide application. Achieving multiple year control would allow for the treatment of additional areas without having to continually re-treat in the same plots. Though this will depend upon site location, water flow, and distance from other Eurasian watermilfoil infestations that would re-colonize an already treated area.

The combination herbicide treatment was less selective than applying triclopyr alone. Using triclopyr alone would not have been effective in plot 8, as the necessary exposure time would not have been met to achieve acceptable results. Therefore, the use of triclopyr alone will not be conducive to all places in the reservoir, especially in areas of increased water-exchange; these areas will need the combination treatment to meet CET requirements. The potential short term impacts of herbicide applications on the native plant community should not overshadow the

long-term effects that Eurasian watermilfoil will have if left unmanaged. Species such as leafy pondweed (*Potamogeton foliosus*) and elodea which are widespread in Noxon recovered by 52 WAT to levels similar or greater than what was observed during the pretreatment survey in plot 8. There is a native propaglue bank present in Noxon that will allow the native community to recover following Eurasian watermilfoil management.

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Table 1. Aquatic plant occurrence in plot 7 herbicide (triclopyr alone) treatment area in Noxon Rapids Reservoir, MT 2010-2011. Differences between sampling events were determined at a $p < 0.05$ significance level using the McNemars test. An asterisk indicates a significant change from the pretreatment occurrence for each species. Mean species richness (±1SE) data were separated using the LSD method, values within a row sharing the same letter are not different at $p < 0.05$ significance level.

Plant Species	**Common Name**	**0 WAT % Occurrence**	**7 WAT % Occurrence**	**52 WAT % Occurrence**
Ceratophyllum demersum	Coontail	38	44	61
***Chara* sp.**	Muskgrass	16	19	21
Elodea canadensis	Elodea	47	47	73*
Heteranthera dubia	Water stargrass	9	6	6
Myriophyllum sibiricum	Northern watermilfoil	38	22	24
Myriophyllum spicatum	Eurasian watermilfoil	50	16*	12*
Potamogeton crispus	Curlyleaf pondweed	81	50*	67
Potamogeton foliosus	Leafy pondweed	31	16	42
Potamogeton illinoensis	Illinois pondweed	0	3	0
Potamogeton richardsonii	Clasping-leaved pondweed	13	22	24
Ranunculus aquatilis	White water-buttercup	22	19	24
Stuckenia pectinata	Sago pondweed	59	50	42
Species Richness		3.8 ± 0.3a	3.0 ± 0.3b	3.9 ± 0.3a
Native Richness		2.6 ± 0.2a	2.4 ± 0.2a	3.2 ± 0.3a
Non-native Richness		1.2 ± 0.1a	0.6 ± 0.1b	0.8 ± 0.1b

Table 2. Aquatic plant occurrence in plot 8 herbicide (triclopyr + endothall) treatment area in Noxon Rapids Reservoir, MT 2010-2011. Differences between sampling events were determined at a $p < 0.05$ significance level using the McNemars test. An asterisk indicates a significant change from the pretreatment occurrence for each species. Mean species richness (±1SE) data were separated using the LSD method, values within a row sharing the same letter are not different at $p < 0.05$ significance level.

Plant Species	**Common Name**	**0 WAT % Occurrence**	**7 WAT % Occurrence**	**52 WAT % Occurrence**
Ceratophyllum demersum	Coontail	57	37	30
***Chara* sp.**	Muskgrass	9	37*	8
Elodea canadensis	Elodea	31	51	65*
Heteranthera dubia	Water stargrass	3	3	5
Myriophyllum sibiricum	Northern watermilfoil	40	3*	8*
Myriophyllum spicatum	Eurasian watermilfoil	63	9*	5*
Potamogeton crispus	Curlyleaf pondweed	74	3*	43*
Potamogeton foliosus	Leafy pondweed	11	0*	19
Potamogeton illinoensis	Illinois pondweed	3	0	0
Potamogeton richardsonii	Clasping-leaved pondweed	31	3*	3*
Ranunculus aquatilis	White water-buttercup	46	20	22
Stuckenia pectinata	Sago pondweed	40	3*	19
Vallisneria americana	Wildcelery	0	6	0
Species Richness		3.9 ± 0.3a	1.7 ± 0.2b	2.4 ± 0.3b
Native Richness		2.5 ± 0.3a	1.6 ± 0.2b	2.0 ± 0.3b
Non-native Richness		1.3 ± 0.1a	0.1 ± 0.1b	0.5 ± 0.1c

Table 3. Aquatic plant occurrence in plot 2 untreated reference area in Noxon Rapids Reservoir, MT 2010-2011. Differences between sampling events were determined at a $p < 0.05$ significance level using the McNemars test. An asterisk indicates a significant change from the pretreatment occurrence for each species. Mean species richness (±1SE) data were separated using the LSD method, values within a row sharing the same letter are not different at $p < 0.05$ significance level.

Plant Species	**Common Name**	**0 WAT % Occurrence**	**7 WAT % Occurrence**	**52 WAT % Occurrence**
Butomus umbellatus	Flowering rush	0	0	3
Ceratophyllum demersum	Coontail	61	53	61
***Chara* sp.**	Muskgrass	6	14	19
Elodea canadensis	Elodea	50	75*	70
Heteranthera dubia	Water stargrass	11	8	17
Myriophyllum sibiricum	Northern watermilfoil	11	0*	6
Myriophyllum spicatum	Eurasian watermilfoil	67	80	86
Najas flexilis	Slender naiad	0	0	3
Potamogeton crispus	Curlyleaf pondweed	75	61	55*
Potamogeton foliosus	Leafy pondweed	31	22	58*
Potamogeton illinoensis	Illinois pondweed	17	14	3
Potamogeton praelongus	Whitestem pondweed	3	3	5
Potamogeton richardsonii	Clasping-leaved pondweed	31	17	24
Ranunculus aquatilis	White water-buttercup	6	6	3
Stuckenia pectinata	Sago pondweed	31	58*	29
Species Richness		3.9 ± 0.3a	4.1 ± 0.3a	4.5 ± 0.3a
Native Richness		2.6 ± 0.2a	2.7 ± 0.2a	3.1 ± 0.3a
Non-native Richness		1.4 ± 0.1a	1.4 ± 0.1a	1.5 ± 0.1a

Table 4. Aquatic plant occurrence in plot 4 untreated reference area in Noxon Rapids Reservoir, MT 2010-2011. Differences between sampling events were determined at a $p < 0.05$ significance level using the McNemars test. An asterisk indicates a significant change from the pretreatment occurrence for each species. Mean species richness (±1SE) data were separated using the LSD method, values within a row sharing the same letter are not different at $p < 0.05$ significance level.

Plant Species	Common Name	0 WAT % Occurrence	7 WAT % Occurrence	52 WAT % Occurrence
Butomus umbellatus	Flowering rush	7	0*	0*
Ceratophyllum demersum	Coontail	50	67	50
***Chara* sp.**	Muskgrass	7	0*	3
Elodea canadensis	Elodea	30	40	53
Heteranthera dubia	Water stargrass	3	10	17
Myriophyllum sibiricum	Northern watermilfoil	33	40	33
Myriophyllum spicatum	Eurasian watermilfoil	30	27	20
Nitella sp.	Nitella	0	13*	0
Potamogeton crispus	Curlyleaf pondweed	46	3*	20*
Potamogeton foliosus	Leafy pondweed	13	30	37
Potamogeton illinoensis	Illinois pondweed	3	0	3
Potamogeton richardsonii	Clasping-leaved pondweed	20	10	20
Ranunculus aquatilis	White water-buttercup	20	10	13
Stuckenia pectinata	Sago pondweed	23	17	27
Species Richness		2.7 ± 0.4a	2.7 ± 0.3a	2.9 ± 0.4a
Native Richness		2.0 ± 0.3a	2.3 ± 0.3a	2.6 ± 0.4a
Non-native Richness		0.8 ± 0.1a	0.3 ± 0.1b	0.4 ± 0.1b

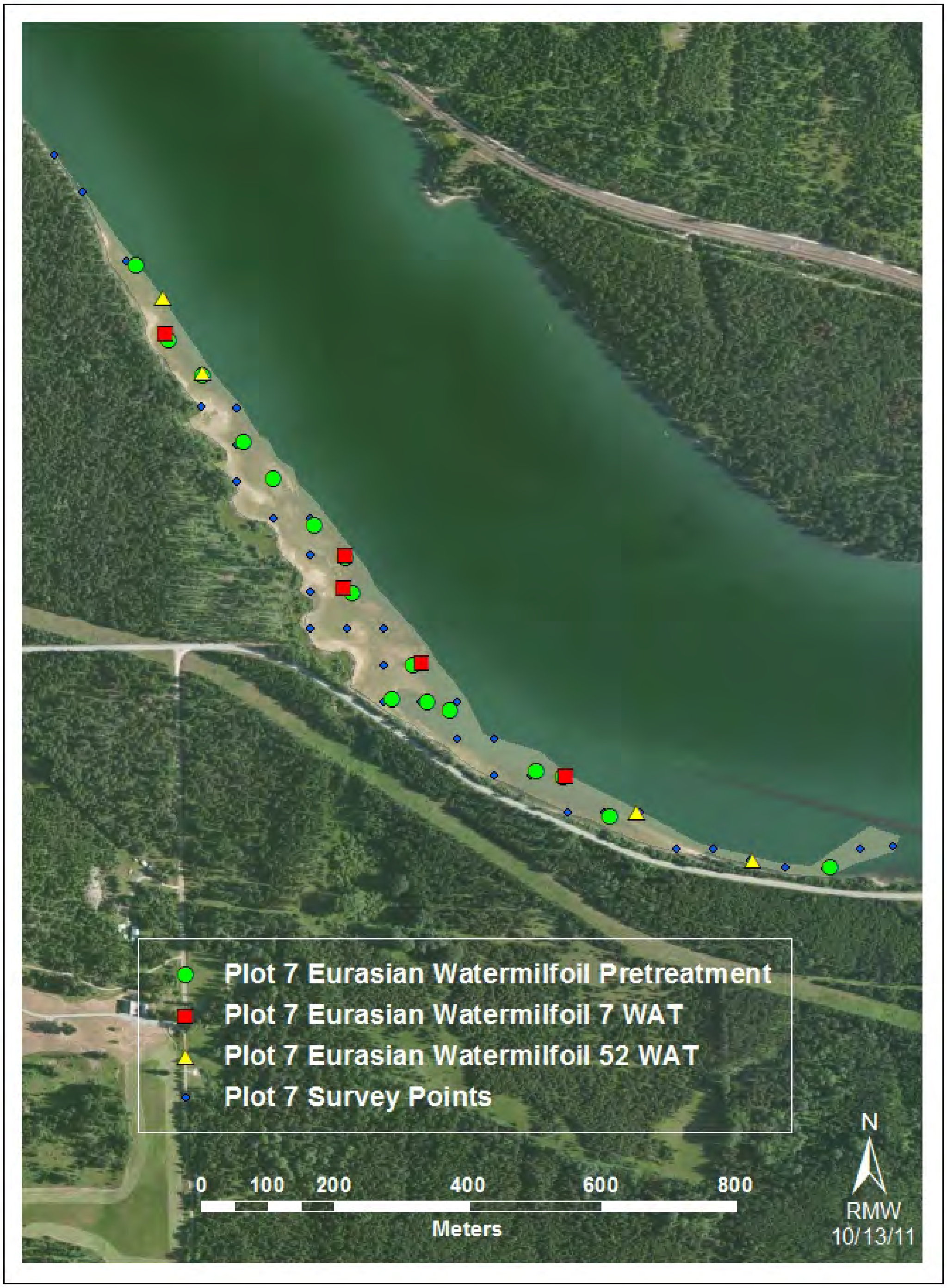

Figure 1. Locations of Eurasian watermilfoil pretreatment, 7 weeks after treatment, and 52 weeks after treatment in plot 7, which received an application of triclopyr alone.

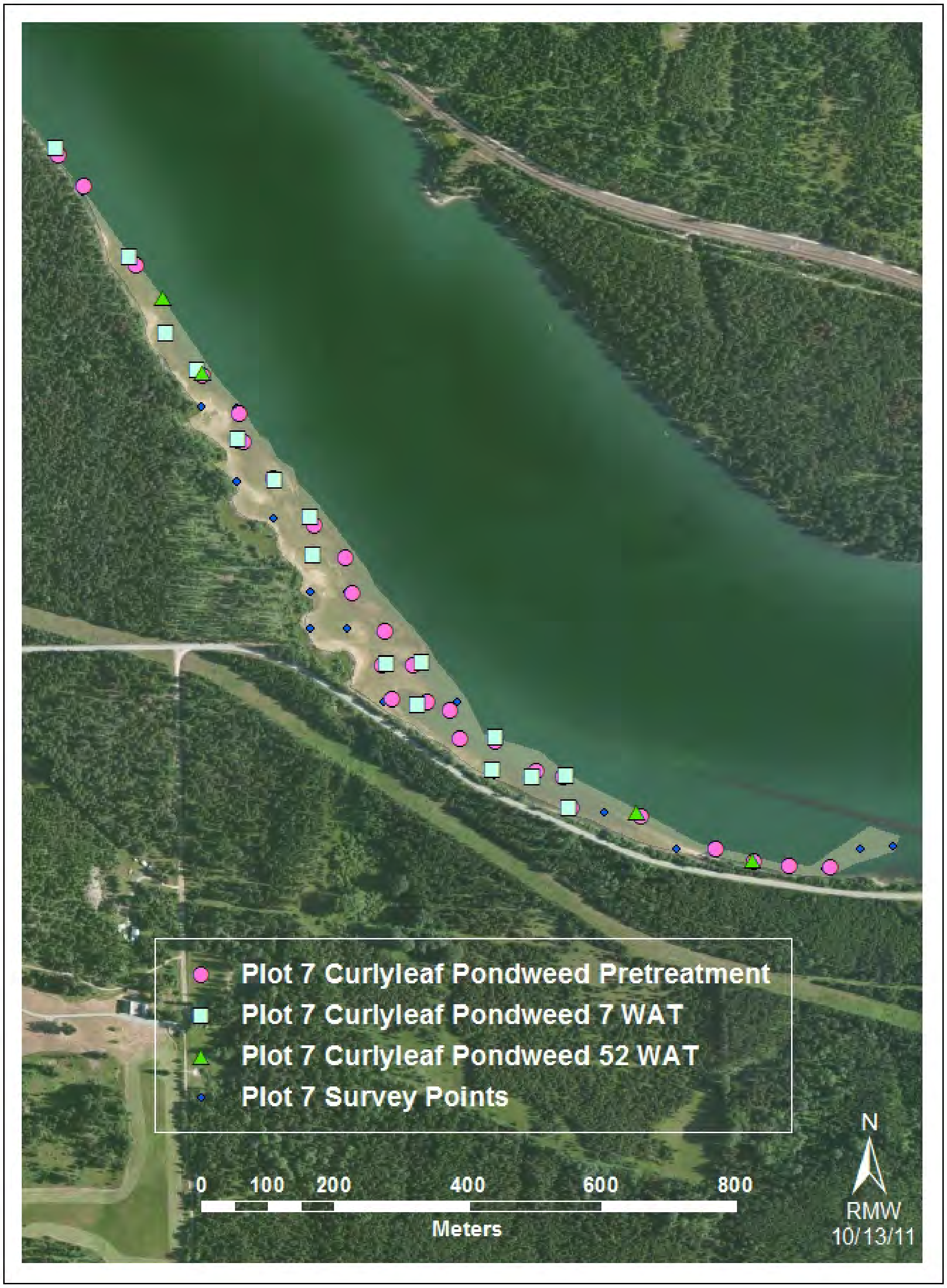

Figure 2. Locations of curlyleaf pondweed pretreatment, 7 weeks after treatment, and 52 weeks after treatment in plot 7, which received an application of triclopyr alone.

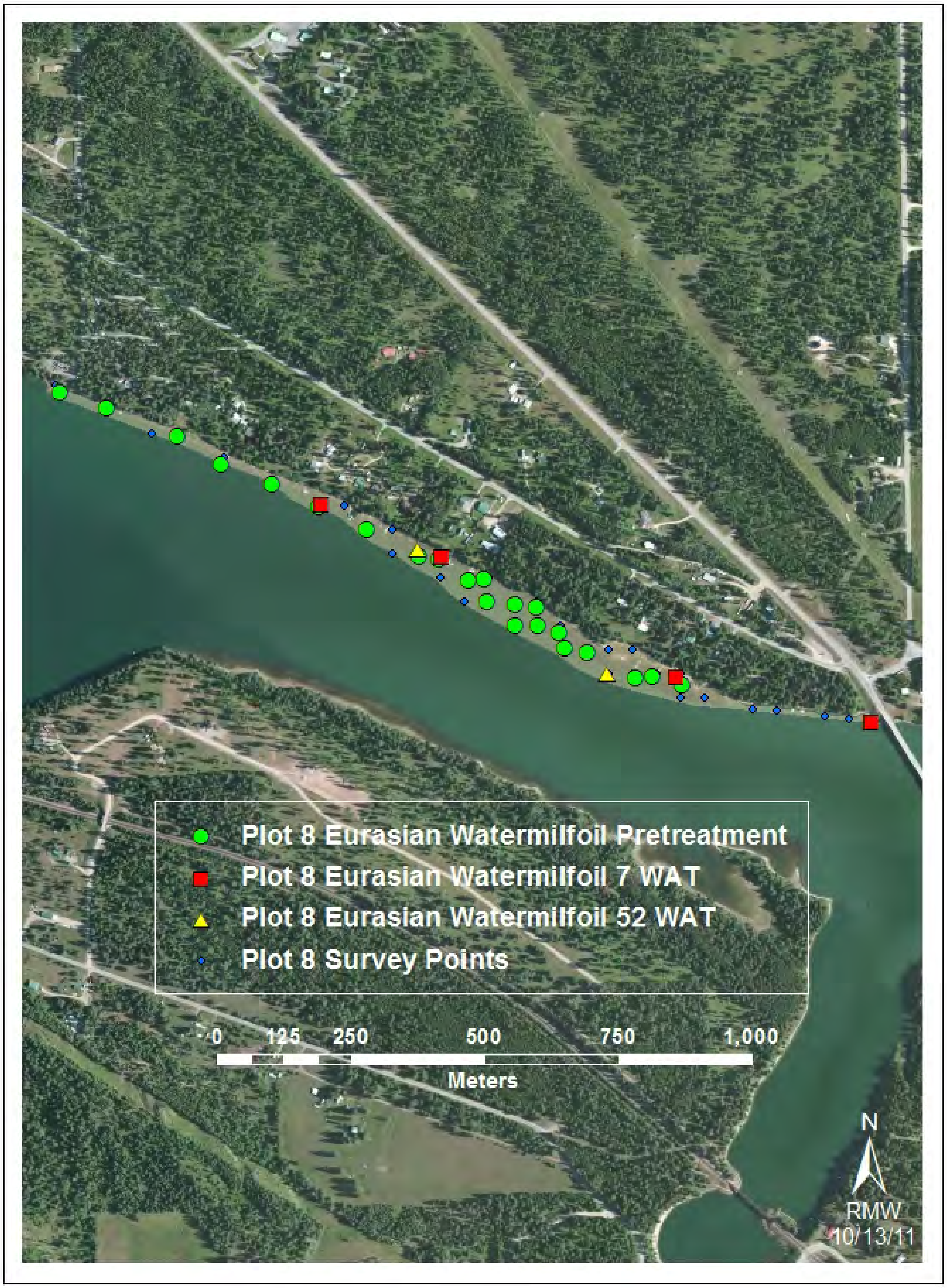

Figure 3. Locations of Eurasian watermilfoil pretreatment, 7 weeks after treatment, and 52 weeks after treatment in plot 8, which received an application of triclopyr + endothall.

Figure 4. Locations of curlyleaf pondweed pretreatment, 7 weeks after treatment, and 52 weeks after treatment in plot 8, which received an application of triclopyr + endothall.

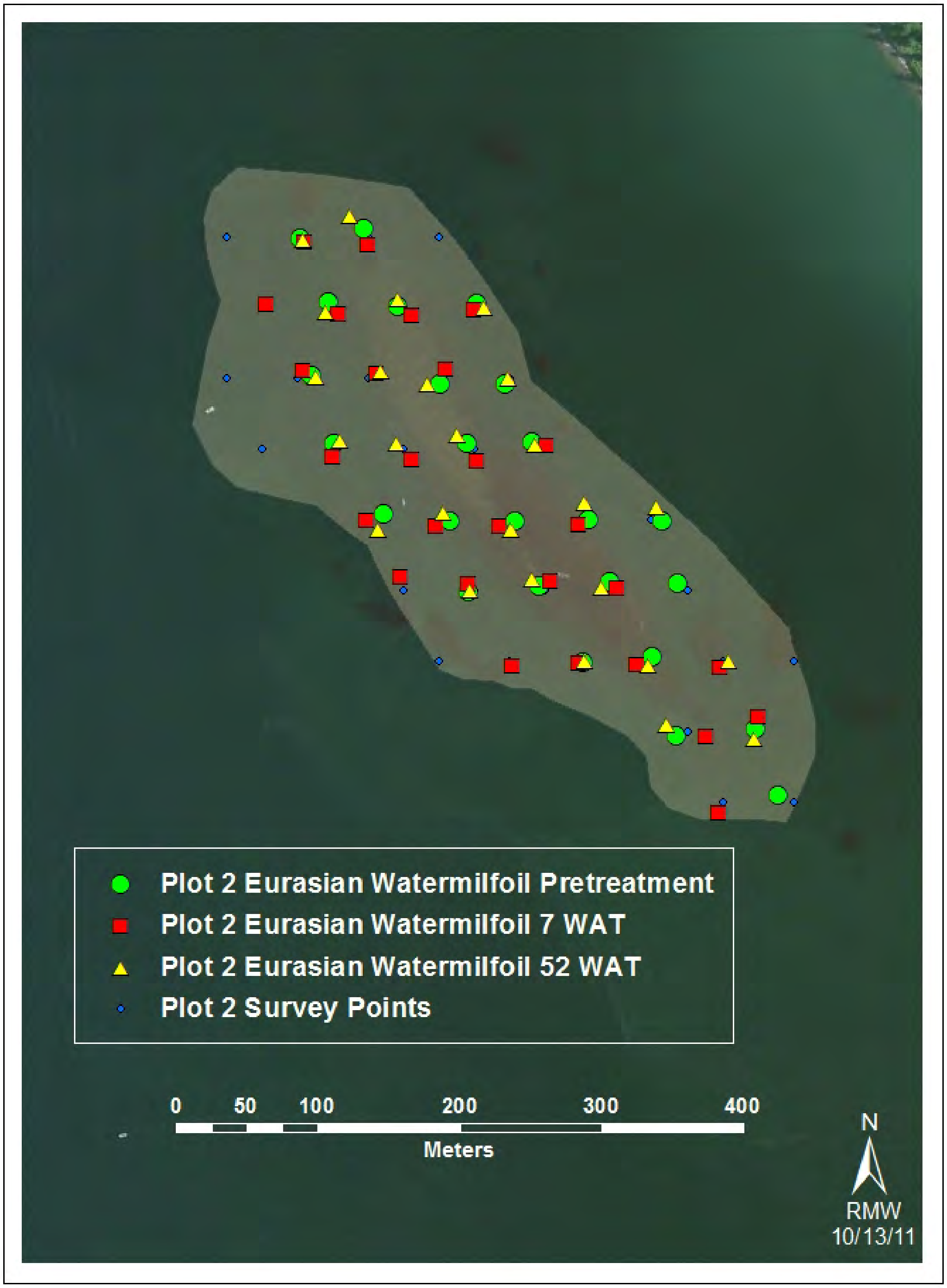

Figure 5. Locations of Eurasian watermilfoil pretreatment, 7 weeks after treatment, and 52 weeks after treatment in plot 2, which served as an untreated reference plot.

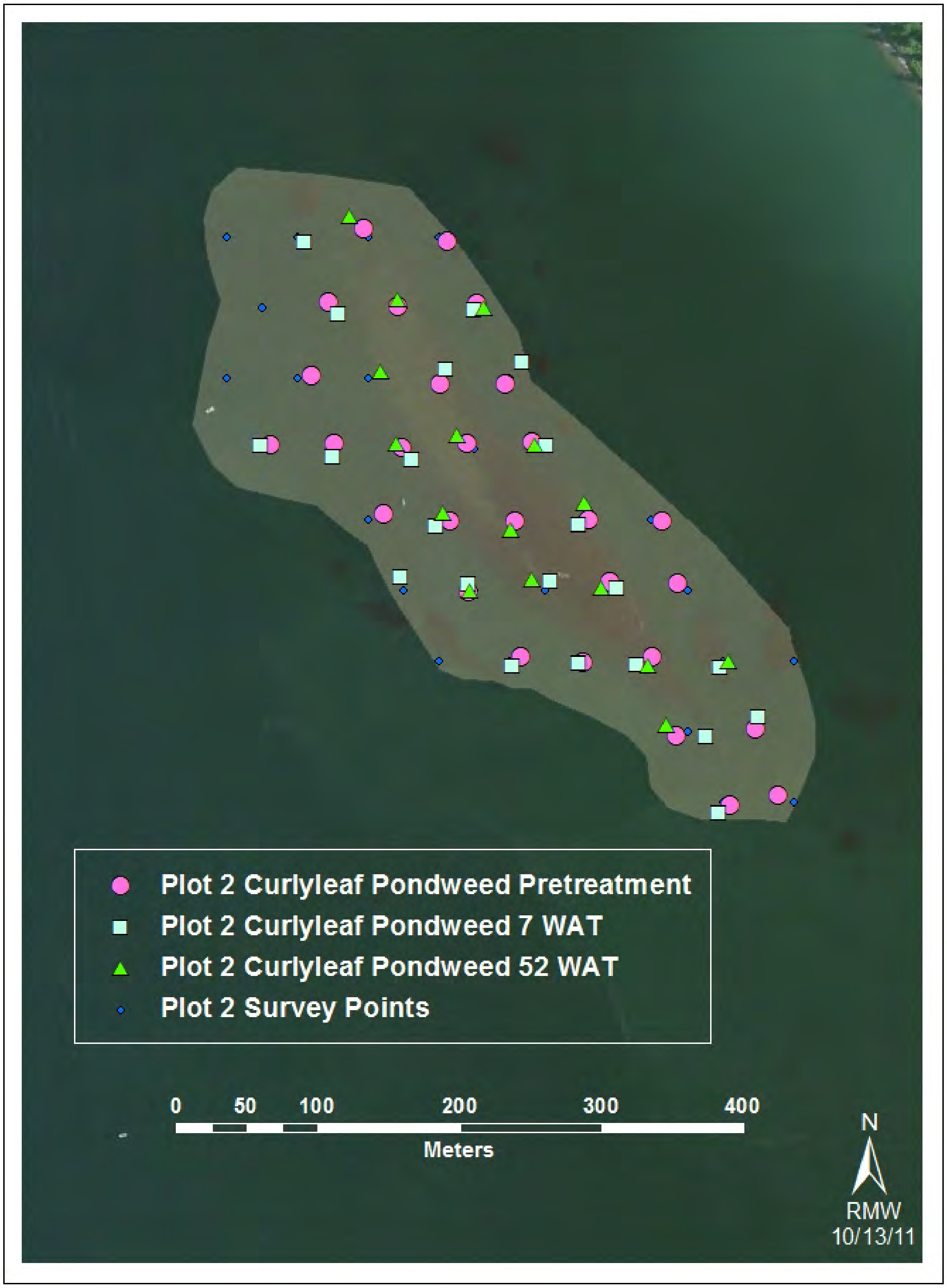

Figure 6. Locations of curlyleaf pondweed pretreatment, 7 weeks after treatment, and 52 weeks after treatment in plot 2, which served as an untreated reference plot.

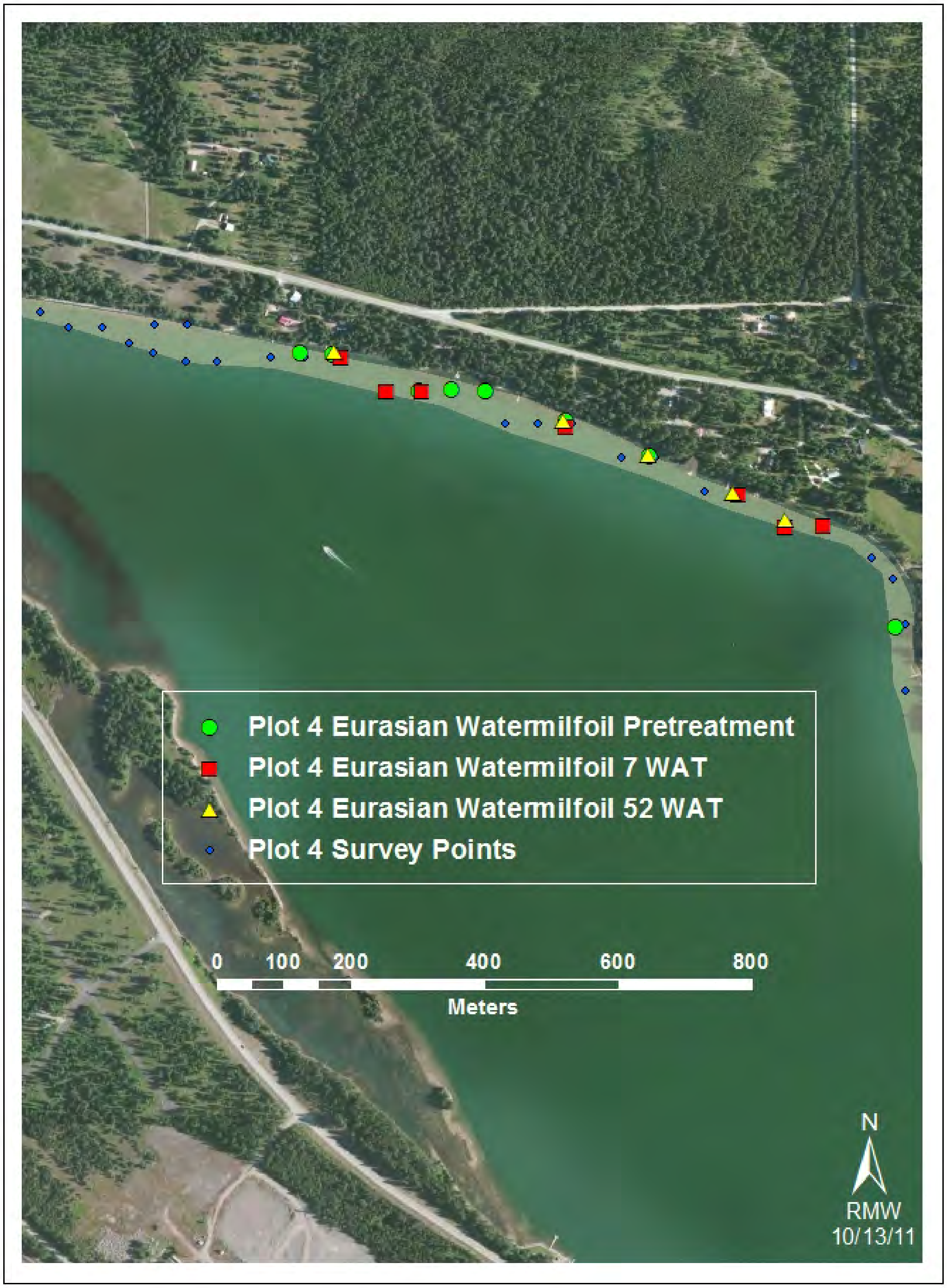

Figure 7. Locations of Eurasian watermilfoil pretreatment, 7 weeks after treatment, and 52 weeks after treatment in plot 4, which served as an untreated reference plot.

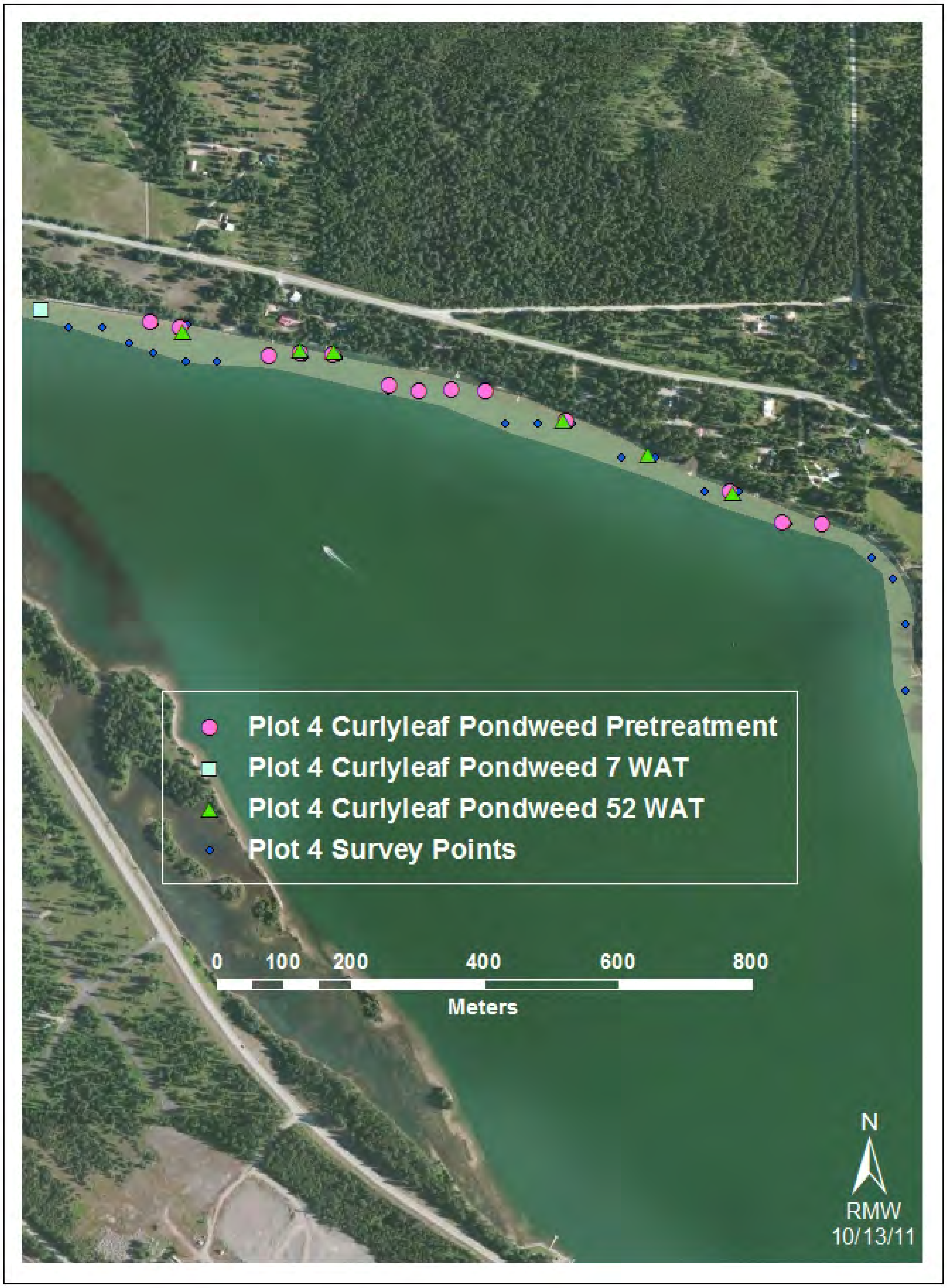

Figure 8. Locations of curlyleaf pondweed pretreatment, 7 weeks after treatment, and 52 weeks after treatment in plot 4, which served as an untreated reference plot.